

Pericardial effusion after cardiac surgery: incidence, site, size, and haemodynamic consequences

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Abstract

Objective—To evaluate the incidence, characteristics, and haemodynamic consequences of pericardial effusion after cardiac surgery.

Design—Clinical, echocardiographic, and Doppler evaluations before and 8 days after cardiac surgery; with echocardiographic and Doppler follow up of patients with moderate or large pericardial effusion after operation.

Setting—Patients undergoing cardiac surgery at a tertiary centre.

Patients—803 consecutive patients who had coronary artery bypass grafting (430), valve replacement (330), and other types of surgery (43). 23 were excluded because of early reoperation.

Main outcome measures—Size and site of pericardial effusion evaluated by cross sectional echocardiography and signs of cardiac tamponade detected by ultrasound (right atrial and ventricular diastolic collapse, left ventricular diastolic collapse, distension of the inferior vena cava), and Doppler echocardiography (inspiratory decrease of aortic and mitral flow velocities).

Results—Pericardial effusion was detected in 498 (64%) of 780 patients and was more often associated with coronary artery bypass grafting than with valve replacement or other types of surgery; it was small in 68.4%, moderate in 29.8%, and large in 1.6%. Loculated effusions (57.8%) were more frequent than diffuse ones (42.2%). The size and site of effusion were related to the type of surgery.

None of the small pericardial effusions increased in size; the amount of fluid decreased within a month in most patients with moderate effusion and in a few (7 patients) developed into a large effusion and cardiac tamponade. 15 individuals (1.9%) had cardiac tamponade; this event was significantly more common after valve replacement (12 patients) than after coronary artery bypass grafting (2 patients) or other types of surgery (1 patient after pulmonary embolectomy). In patients with cardiac tamponade aortic and mitral flow velocities invariably decreased during inspiration; the echocardiographic signs were less reliable.

Conclusions—Pericardial effusion after cardiac surgery is common and its size and site are related to the type of surgery.

Cardiac tamponade is rare and is more common in patients receiving oral anti-coagulants. Echo-Doppler imaging is useful for the evaluation of pericardial fluid accumulations after cardiac surgery. It can identify effusions that herald cardiac tamponade.

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Pericardial effusion is not a rare complication of cardiac surgery.^{1,2} Though it is generally reversible and not life threatening, it may sometimes evolve towards cardiac tamponade. Echocardiography is the best diagnostic technique.³⁻⁵ Cross sectional studies showed that postoperative, pericardial effusions are often loculated and that even small amounts of fluid in the postero-medial wall, posterolateral wall, or along the free wall of the right atrium and right ventricle can considerably disturb the heart function.⁶⁻⁹

We studied the postoperative accumulation of fluid in the pericardium; its relations with type of cardiac surgery, and the characteristics of effusions leading to cardiac tamponade.

Patients and methods

We studied 803 consecutive patients (495 men and 308 women, aged 14-83 (mean (SD) 59.4 (11.6)) who underwent cardiac surgery at the Institute of Cardiology, University of Milan, between February 1992 and January 1993. Four hundred and thirty had coronary artery bypass, 158 aortic valve replacement, 129 mitral valve replacement, 43 combined mitral and aortic valve replacement, and 43 other types of surgery. Those with preoperative effusions were excluded from the study.

All patients underwent cardiopulmonary bypass; the pericardium was left open and not approximated in patients who had coronary artery bypass and partially reapproximated in those who had valve replacement. Pericardial drainage tubes were always positioned at the end of the surgical procedure and withdrawn in the next 24 hours; patients with postoperative bleeding (> 150 ml/h for more than 4 h) who had early reoperation (within 48 h) were excluded from the study.

ECHOCARDIOGRAPHIC EVALUATION

M mode, cross sectional, and Doppler echocardiograms were recorded in all patients before and 8 days after surgery with a

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Hewlett-Packard ultrasound unit (model Sonos 1000 and Sonos 1500, Hewlett-Packard, Andover, Massachusetts, USA). The imaging views were the parasternal long and short axis; apical four chamber, two chamber, and long-axis; and subcostal. Pulsed Doppler echocardiograms of the mitral and aortic flow were taken from the apical views.

The side of effusion was classified as: diffuse (circumferential effusion) and regional loculated (effusion along the anterior right and/or left ventricular wall or the right atrial, the left atrial, postero-lateral left ventricular, or right ventricular walls). Diffuse effusions were categorised as small (1–9 mm), moderate (10–19 mm), or large (> 20 mm) based on the sum of the anterior and posterior pericardial spaces¹⁰; loculated effusions were categorised as small (< 5 mm), moderate (5–9 mm), and large (> 10 mm), according to the maximal length of the pericardial space in the involved segment.

Diagnosis of cardiac tamponade was based on the following echocardiographic and Doppler signs: right atrial collapse,¹¹ right ventricular collapse,¹² left ventricular collapse,⁷ distension of the inferior vena cava with blunted inspiratory response,¹³ inspiratory decrease in left ventricular inflow (mitral flow) and outflow (left ventricular outflow tract) velocities. A significant inversion of the right atrial free wall during more than a third of the cardiac cycle was classified as right atrial collapse; right ventricular collapse was defined as persistent diastolic inversion of the right ventricular free wall noted after opening of the mitral valve; left ventricular collapse consisted of an inward early diastolic collapse of the left ventricular free wall; distension of the inferior vena cava was defined as a decrease of < 35% of the diameter of the proximal inferior vena cava with inspiration measured by M mode echocardiography in a subcostal cross sectional view, during quiet respiration; an inspiratory decrease of > 25% of flows in the mitral and left ventricular outflow tracts was regarded as significant.^{14 15}

FOLLOW UP

Aspirin (250 mg once a day) or dipyridamole (75 mg three times a day) was routinely given to patients who had coronary artery bypass grafting, and anticoagulants were routinely given to patients operated on for valve replacement. The follow up varied according to the severity of pericardial effusion. Patients with no or small pericardial effusion were discharged from the hospital on postoperative day 9 and underwent cardiac rehabilitation

for 14 days; one month later all of them were re-evaluated clinically and radiographically. In patients presenting with moderate or large pericardial effusions or echocardiographic signs of cardiac tamponade, echocardiography was performed daily (postoperative day 9–25). The decision to perform percutaneous or surgical pericardiocentesis was based on clinical evidence of raised venous pressure, hypotension and pulsus paradoxus. Percutaneous pericardiocentesis guided by echocardiography was carried out according to a method devised by our group¹⁶; we used subxiphoid pericardiotomy only in patients in whom the characteristics of the effusion contraindicated a percutaneous approach.¹⁷ Symptomfree patients with a large pericardial effusion without signs of cardiac tamponade were treated medically and the echocardiogram was repeated daily.

STATISTICAL ANALYSIS

Groups were compared by χ^2 analysis; results were regarded as significant when $P < 0.05$.

Results

Twenty three of the 803 consecutive patients were excluded from the study because of bleeding or cardiac tamponade requiring early reoperation (< 2 days). Seventeen of these patients had undergone coronary artery bypass grafting and six had had valve replacement.

INCIDENCE AND SIZE

Table 1 shows the incidence and size of pericardial effusions in the study population and their distribution according to the type of operation. Effusion was detected in 498 (64%) of the 780 patients and was more often associated with coronary artery bypass grafting (75%) than with valve replacement (52%) or other types of surgery (46.5%). It was classified as small in 341 (68.4% of cases with effusion), moderate in 149 (29.9%), and large in 8 (1.6%). Small pericardial effusions were slightly more frequent after valve replacement (76% of cases with effusion in this group) than after coronary artery bypass (64%). For moderate effusions the reverse was true. All these differences were statistically significant.

SITE

Effusions were loculated in 288 patients (57.8%) and diffuse in 210 (42.2%); 39.6% of the loculated effusions were anterior, 24.6% were postero-lateral and 12.5% were anterior and postero-lateral (table 2). Isolated effusions at the level of right atrium (5.6%), right ventricle (0.3%), and left atrium (0.3%) were uncommon. Table 2 also shows the relation between the type of surgery and site of effusion. After valve replacement diffuse fluid accumulations were more frequent (55%) than loculated ones (45%); whereas after coronary artery bypass grafting loculated effusions were more common (63.5%) than diffuse ones (36.5%). The site was also related

Table 1 Incidence and size of pericardial effusion

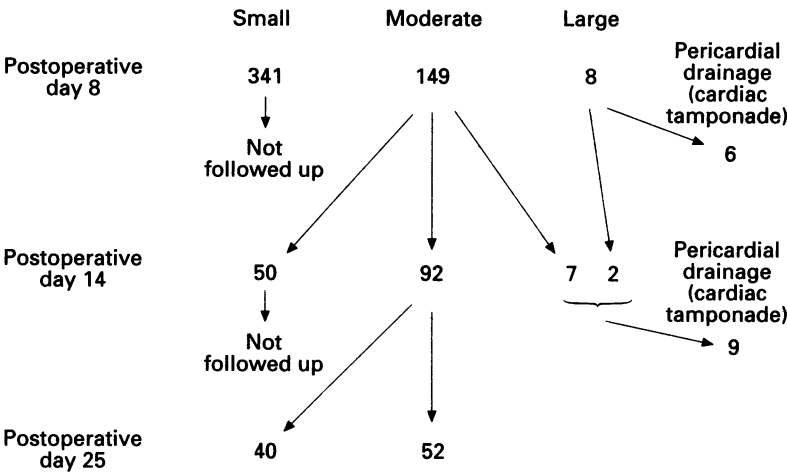
	Total (%)	CABG (%)	Valve replacement (%)	Other (%)
Number	780	413	324	43
No effusion	282 (36)	104 (25)*	155 (48)	23 (53.5)
Effusion:	498 (64)	309 (75)*	169 (52)	20 (46.5)
Small	341 (68.4)	196 (64)†	128 (76)	17 (85)
Moderate	149 (30)	109 (35)†	38 (22)	2 (10)
Large	8 (1.6)	4 (1)	3 (2)	1 (5)

CABG, coronary artery bypass grafting. * $P < 0.001$ compared with valve replacement group and other group. † $P < 0.005$ compared with valve replacement group and other group.

Table 2 Site of pericardial effusion

	Total (%)	CABG (%)	Valve replacement (%)	Other (%)
Number	498	309	169	20
Diffuse	210 (42.2)	113 (36.5)*	95 (55)	4 (20)
Loculated:	288 (57.8)	196 (63.5)*	76 (45)	16 (80)
Anterior (A)	114 (39.6)	98 (50)*	13 (17)	3 (18.7)
Postero-lateral (P-L)	71 (24.6)	33 (16.8)	32 (42)†	6 (37.5)
A + P-L	36 (12.5)	31 (15.8)*	4 (5.2)	1 (6.2)
RA	16 (5.6)	3 (1.5)	10 (13)	3 (18.7)
RV	1 (0.3)	—	1 (0.1)	—
RA + RV	8 (2.8)	4 (2.0)	3 (4.0)	1 (6.2)
LA	1 (0.3)	1 (0.5)	—	—
RA + LA	5 (1.7)	2 (1.0)	3 (4.0)	—
Post + RA or RV	17 (6.0)	12 (6.1)	4 (5.2)	1 (6.2)
A + RA or RV	19 (6.6)	12 (6.1)	6 (7.8)	1 (6.2)

CABG, coronary artery bypass grafting; VR, valve replacement; RA, right atrial; RV, right ventricular; LA, left atrial. P < 0.001 compared with valve replacement and other groups. P < 0.001 compared with CABG group.



Follow up of patients with pericardial effusion.

to the type of surgery: anterior effusions were more common after coronary artery bypass grafting (50% v 13% after valve replacement; P < 0.001) and posterolateral ones after valve replacement (42% v 16.8% after grafting P < 0.001).

CLINICAL AND ECHOCARDIOGRAPHIC FOLLOW UP AND CARDIAC TAMPONADE

The figure summarises the results of follow up. No small effusion developed into cardiac tamponade or caused haemodynamic embarrassment either in the short-term or within a month of operation. Among the 149 patients with moderate effusion, the amount of pericardial fluid decreased in 90 (between day 10 and 25), remained unchanged in 52, and developed as cardiac tamponade in seven.

Each of the eight patients with large effusions also had cardiac tamponade requiring percutaneous pericardiocentesis or sub-xiphoid pericardiotomy. Tamponade occurred early (< 10 days) in six patients and late in nine (from day 14 to day 23). The effusion was large and diffuse in 12 and large and loculated in three. Cardiac tamponade was significantly more common after valve replacement (12 patients) than after coronary artery bypass (2 patients) or other types of surgery (1 patient who had undergone pulmonary embolectomy). In one patient effusion recurred after pericardiocentesis and was refractory to pharmacological treatment; he was referred for late pericardiotomy. In one patient (aortic valve replacement) with a loculated effusion a large pericardial clot developed which compressed the right atrium and required surgical removal (postoperative day 8).

Table 3 shows the type and frequency of Doppler and echocardiographic findings of cardiac tamponade. We invariably recorded an inspiratory decrease (> 25%) in the velocity of flow through the aortic and mitral valves. Five patients had the echocardiographic signs of right atrial collapse, right ventricular collapse and distension of the inferior vena cava, eight patients had two of these signs, and two had one. In four patients moderate pericardial effusion was associated with one or two echocardiographic signs of cardiac tamponade, but not with clinical evidence of haemodynamic embarrassment or with Doppler signs of cardiac tamponade. Within 25 days we recorded complete resolution of pericar-

Table 3 Echocardiographic signs of cardiac tamponade

Patient	Operation	Effusion size	Effusion location	Fluid removed (ml)	RAC	RVC	IVCP	LVC	IRDV
1	CABG	Large	Diffuse	650	+	+	+	-	+
2	AVR	Large	Loculated	350	+	+	-	-	+
3	AVR	Large	Post-lat + RA	750	+	+	+	-	+
4	MVR	Large	Diffuse	1150	+	+	+	-	+
5	PA	Large	Diffuse	900	+	-	+	-	+
6	AVR	Large	Loculated (clot)	270	+	-	+	-	+
7	MVR	Large	Diffuse	1500	+	+	-	-	+
8	CABG	Large	Diffuse	850	+	+	-	-	+
9	MVR + AVR	Large	Diffuse	550	+	-	-	-	+
10	AVR	Large	Loculated (RA + RV)	500	+	+	+	-	+
11	MVR	Large	Diffuse	650	-	-	+	-	+
12	AVR	Large	Diffuse	750	+	+	+	-	+
13	MVR	Large	Diffuse	700	+	-	+	-	+
14	MVR	Large	Diffuse	800	+	+	-	-	+
15	AVR	Large	Diffuse	800	+	+	-	-	+

AVR, aortic valve replacement; CABG, coronary artery bypass grafting; IRDV, inspiratory reduction of Doppler velocities of mitral and aortic flow; IVCP, distension of the inferior vena cava; LVC, left ventricular collapse; MVR, mitral valve replacement; PA, pulmonary arterioectomy; RAC, right atrial collapse; RVC, right ventricular collapse.

dial effusion in two patients or disappearance of echocardiographic signs of cardiac tamponade in two.

Discussion

To our knowledge ours is the largest prospective study based on cross sectional and Doppler evaluation of the size, site, and haemodynamic consequences of pericardial effusion after cardiac surgery. It showed that after cardiac surgery effusion into the pericardium is frequent and generally small or moderate, and that it is significantly more common after coronary artery bypass (75% of cases) than after valve replacement (52%). Weitzman *et al* in a study performed with M mode echocardiography in a smaller population, did not establish a relation between the incidence of pericardial fluid accumulation and type of surgery.¹ The discrepancy may be attributable to the greater numbers of patients evaluated in our study, to the use of cross sectional echocardiography, or to differences in surgical procedures (extensive use of internal mammary artery grafting). We also showed that only 2% of patients had large pericardial effusions by postoperative day 8; that a moderate effusion rarely developed into a large one (seven out of 149 cases); and that the time taken for moderate effusions to reduce or resolve varied considerably (between postoperative day 10 and 25 in 50% of cases).

In our series the effusion was loculated in 57.8% of cases, and effusions in the anterior, postero-lateral and anterior + postero-lateral pericardial spaces were more common than diffuse circumferential effusions. Isolated effusion along the right atrial wall can compress the heart and can be difficult to diagnose in patients with postoperative low output failure.^{8,9} We confirmed that about 6% of our patients had isolated effusions.

Diffuse effusion tended to be associated with valve replacement (54.8% of postoperative effusions) and loculated effusion were more common after coronary artery bypass grafting (63.6% of postoperative effusions). Half the patients who had had coronary artery bypass grafting had an anterior effusion whereas patients who had valve replacement were more likely to have a postero-lateral effusion. Inflammation or bleeding caused fluid to accumulate posteriorly and laterally whereas loculated anterior effusions were more common after coronary artery bypass; this may be because the internal thoracic wall bleeds more frequently during routine internal mammary artery grafting.

As in other studies,^{1,18-21} few (1.9%) of the patients developed cardiac tamponade. In the earlier reports postoperative tamponade occurred in 0.6–6%. Most patients with cardiac tamponade were taking anticoagulants, 12 had had a valve replacement, and one had been operated for pulmonary embolism. The late appearance of cardiac tamponade (postoperative day 8–23) suggests a link with the anticoagulant treatment. Only two patients required pericardiocentesis after coronary

artery bypass: both were taking aspirin. Reapproximation of the pericardium after valve replacement may increase the predisposition to cardiac tamponade. Though closure of the pericardium reduces postoperative bleeding and protects the heart when sternotomy has to be repeated^{22,23} it also predisposes to tamponade.^{24,25}

Doppler examination was useful in the diagnosis of cardiac tamponade. All patients with tamponade and none of those with moderate effusion had a decrease of > 25% in mitral and aortic flow velocities during inspiration. In five patients with cardiac tamponade echocardiography showed right atrial and right ventricular collapse and distension of the inferior vena cava; eight cases showed two of these signs, and two had one echocardiographic sign. In four patients with moderate pericardial effusion without clinical cardiac tamponade, one or two echocardiographic signs of cardiac tamponade were present. These results accord with those of Schutzman *et al* who compared Doppler and cross sectional echocardiography for the assessment of pericardial effusion and showed that Doppler signs are more specific and sensitive for tamponade than echocardiographic ones.¹⁵ This may be because right atrial and right ventricular collapse and inferior vena cava distension are influenced by numerous haemodynamic and anatomical factors, including intravascular volume and myocardial thickness.²⁶

We did not find any instances of left ventricular diastolic collapse. This sign was described by Chuttani *et al* in 18 cases in a retrospective study of a large series of operated patients.⁷ It is an uncommon but useful sign in patients with pulmonary hypertension, when other signs of cardiac tamponade may be absent.²⁷ In one patient ultrasound showed a pericardial clot compressing the right atrium and causing cardiac tamponade; this rare complication can be diagnosed by both transthoracic²⁸ and transoesophageal⁹ echocardiography.

Cardiac tamponade, once diagnosed, requires decompression and the method used should be safe, simple, and rapid. Percutaneous pericardiocentesis guided by echocardiography may be an alternative to subxiphoid pericardiotomy in tamponade caused by postoperative pericardial effusion.¹⁷ Guidance by a combination of cross sectional ultrasound monitoring and the Tuohy needle technique improves placement of the catheter, facilitates complete drainage of loculated effusions, and reduces the complications associated with the percutaneous approach.¹⁶ This method is contraindicated if there is too little fluid at the site of needle entry or a loculated pericardial haematoma; in these cases, subxiphoid surgical pericardiotomy is a better method.

LIMITATIONS OF THE STUDY

Weitzman *et al* showed that nearly all important effusions were present by the fifth postoperative day, that they peaked on the tenth day, and resolved within one month.¹ So we

evaluated patients on the eighth postoperative day and repeated ultrasound examinations only in those with moderate or large effusions. Fifty two patients with residual moderate effusion were followed up for a month; none of them had clinical problems then. Patients with no or small effusions (by postoperative day 8) were not followed up echocardiographically. At one month none of them had clinical or radiographic evidence of pericardial fluid accumulation; none the less, follow up studies in those without effusions initially might have provided further evidence that late accumulation of pericardial fluid is uncommon after cardiac surgery.

Diffuse effusions were defined as small, moderate, or large on the basis of the sonoluculent pericardial space posterior and anterior to the heart, and loculated effusions as small, moderate, and large on the basis of the maximal length of the involved region. Terms like small, moderate, large have been given different meanings; some regard pericardial effusions of <500 ml as small, between 500 ml and 1000 ml as moderate, and >1000 ml as large²⁹; others have described effusions of 25–100 ml as small, between 100 ml and 500 ml as moderate, and > 500 ml as large.³⁰ When we used the terms small, moderate, and large to describe loculated effusions we did not mean the volume of pericardial fluid in absolute terms.

This study of a large group of patients showed that pericardial effusion was common after cardiac surgery and that its site and size were related to the type of surgery. Cardiac tamponade was rare and more common in patients taking oral anticoagulants. Cross sectional and Doppler echocardiography was useful in evaluating the accumulation of pericardial fluid after cardiac surgery and enabled us to identify the effusions that developed into cardiac tamponade.

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